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Contribution to:

NIAM 5-1-74
(The Nuclear Fuel Market to About 1990)

and

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Uranium Enrichment Capacity)

Nuclear Power and the Demand for Uranium Enrichment Services

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Nuclear Power and the Demand for Uranium Enrichment Services

Introduction

The scheduled growth of nuclear electric generating capacity has created a booming market for uranium services which probably will exceed $5 billion annually by 1990. The total capacity of nuclear powerplants in the West is expected to grow at an annual rate of about 27% through the early 1980s. Major sources of enrichment demand will include the United States, Japan, France, West Germany, the United Kingdom, Spain, and Sweden. Nuclear power development plans of individual countries can be used to describe the short term demand (through 1980) for enriched uranium with some accuracy. However, because of prevailing uncertainties, a more generalized approach based on extrapolations of short term trends together with varying assumptions about future energy consumption patterns must be used to develop a medium term (through about 1990) forecast of enrichment requirements.

The Growth of Nuclear Power

The demand for enriched uranium is directly related to the growth of nuclear electric generating capacity. Although some nations -- primarily the United Kingdom and

France -- have in the past relied on nuclear powerplants fueled with natural uranium, most plants being built today and those planned for future installation will be fueled with enriched uranium. In 1973, about 72% of operating nuclear generating capacity in the West was in enriched uranium-fueled reactors. Despite Canada's own relatively large power program and its efforts to market the CANDU reactor abroad, light water reactors (LWRs) and other types of enriched uranium plants will account for 92% of projected Free World capacity in 1980, with natural uranium reactors being added only in Canada, Argentina, India, and South Korea. The uranium enrichment market in non-Communist countries probably will expand from its present level of about $200 million per year to over $5 billion annually by 1990.

Nuclear energy has been used to generate electricity on a commercial scale since the mid-1950s, but the installation of sizable nuclear capacities was limited by both technology and the high cost of nuclear-generated electricity until the late 1960s. Plants were built for the purpose of gaining construction and operating experience with new technologies rather than for an inherent economy of nuclear power. The potential was there, but it was not until utilities gained confidence that light water reactors

Figure 1

Growth in Non-Communist
Nuclear Generating Capacity

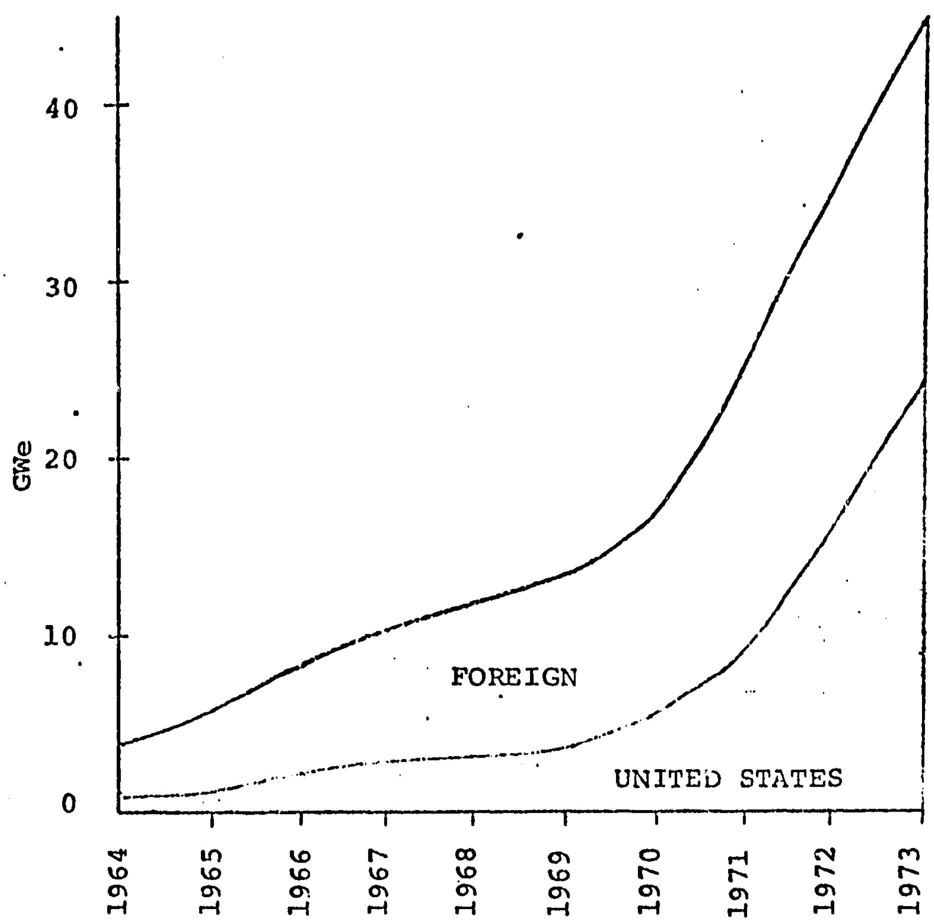

Table 1

Production of Electricity: Contribution of Nuclear Power in Non-Communist Countries, 1973

	Total Gross Electricity Production (billion KWh)	Gross Nuclear Electricity Production (billion KWh)	Percent Nuclear
Switzerland	37.7*	6.2	16.4
United Kingdom	284.4	28.0	9.8
Spain	75.8	6.6	8.7
Canada	267.2*	18.3	6.8
France	183.3*	11.2	6.1
Pakistan	9.0**	0.5	5.6
United States	2,073.6*	87.4	4.2
West Germany	299.0	12.6	4.2
India	63.1	1.9	3.0
Sweden	77.3	2.1	2.7
Italy	143.5	3.1	2.2
Japan	436.4	9.4	2.2
Netherlands	52.6	1.0	1.9

* Reported net production figures have been adjusted to obtain estimated gross production.
** Estimate.

were reliable and could become economically competitive that nuclear power stations began to be constructed on a large scale. The growth of nuclear capacity in the US and other non-Communist countries over the last ten years is indicated in Figure 1. The surge of installation in the early 1970s was more in anticipation of favorable future conditions with larger reactor units than a reflection of actual economics at the time.

At present, nuclear-generated electricity plays only a minor role in total electricity use. In the US during 1973, nuclear power contributed only 4.2% to total US electricity production, and about 1.5% to total energy supply. The contribution of nuclear power to total electricity production in the US is compared to that in other countries in Table 1. The present limited role of nuclear power will, however, be transformed into a major one in the years ahead. As of mid-1974, about 120 nuclear power reactors were in operation in the Free World and over 60 more are now under construction in the US and almost 75 abroad. Throughout the remainder of this decade into the early 1980s total installed nuclear capacity is expected to increase by an average of almost 30% per year in non-Communist countries. The annual rate of growth in the US probably will be about 25%. Table 2 presents a

Table 2

Projected Short Term Non-Communist Nuclear Generating Capacity*
(Gross Electrical Gigawatts)

End of Year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
European Community	12.3	14.3	19.5	29.2	33.2	39.9	53.0	68.1	78.4	90.1
Other OECD Europe	2.7	4.8	5.4	8.0	11.8	18.6	21.6	25.1	29.6	39.3
Canada	2.7	2.7	2.7	3.5	4.2	5.0	6.5	7.3	9.7	12.0
Japan	1.8	5.2	7.4	11.5	16.2	20.6	25.5	33.3	38.9	44.3
Other Countries**	0.7	1.0	1.0	2.4	4.8	6.4	8.7	10.6	16.0	23.0
Total Foreign	20.2	28.0	36.0	54.6	70.2	90.5	115.3	144.4	172.6	208.7
United States	21.7	36.1	47.0	56.2	62.2	69.3	81.6	102.1***	127.0***	155.0 ***
Total Non-Communist	41.9	64.1	83.3	110.8	132.4	159.8	196.9	246.5	299.6	363.7

* Data are based on August 1974 evaluation of individual nuclear powerplants in operation, under construction, or planned.

** Includes Argentina, Brazil, Egypt, India, Iran, Israel, Mexico, Pakistan, Philippines, South Africa, South Korea, Taiwan, Thailand, and Yugoslavia (a Communist country which has ordered the reactor for its first nuclear powerplant from a US company).

*** Data represent USAEC domestic forecast Case D as published in WASH-1139 (74), Nuclear Power Growth, 1974-2000, February 1974, in net electrical gigawatts.

Table 3

Foreign Non-Communist Enriched Uranium Reactors
Operating in 1980 (Projected)

Country	Reactor	Type	Capacity (MWe gross)	Commercial Operation
Austria	Zwentendorf	BWR	732	1976
	Enns	LWR	900-1300	1980
Belgium	Doel-1	PWR	410	1974
	Doel-2	PWR	410	1976
	Tihange-1	PWR	920	1975
	Tihange-2	PWR	920	1980
	Doel-3	PWR	920	1980
Brazil	Angra dos Reis	PWR	657	1977
Finland	Loviisa-1	PWR	440	1977
	Loviisa-2	PWR	440	1978
	Olkiluoto-1	BWR	666	1978
	Olkiluoto-2	BWR	666	1980
France	Chooz	PWR	285	1967
	EL-4	HWGCR	77	1967
	Fessenheim-1	PWR	930	1976
	Fessenheim-2	PWR	930	1976
	Bugey-2	PWR	957	1976
	Bugey-3	PWR	957	1977
	Bugey-4	PWR	957	1978
	Bugey-5	PWR	957	1978
	St. Laurent-3	BWR	1,003	1979
	Gravelines-1	PWR	957	1979
	Gravelines-2	PWR	957	1979
	Tricastin-1	PWR	957	1979
	Tricastin-2	PWR	957	1979
	Dampierre-1	PWR	957	1979
	St. Laurent-4	BWR	1,003	1980
	Gravelines-3	PWR	957	1980
	Gravelines-4	PWR	957	1980
	Tricastin-3	PWR	957	1980
	Tricastin-4	PWR	957	1980
	Dampierre-2	PWR	957	1980
	Gironde-1	PWR	957	1980
India	Tarapur-1	BWR	200	1969
	Tarapur-2	BWR	200	1969
Iran	1st plant	LWR	600	1980
Italy	Garigliano	BWR	160	1964
	Trino Vercellese	PWR	257	1964
	Caorso	BWR	822	1975
	Portocanone-1	PWR	952	1979
	Viterbo-1	BWR	982	1979
	Portocanone-2	PWR	952	1980
	Viterbo-2	BWR	982	1980
Japan	Tsuruga	BWR	357	1969
	Fukushima-1	BWR	460	1970
	Mihama-1	PWR	340	1970
	Mihama-2	PWR	500	1972
	Shimane-1	BWR	460	1974
	Fukushima-2	BWR	784	1974
	Takahama-1	PWR	826	1974
	Fukushima-3	BWR	784	1974
	Hamaoka-1	BWR	540	1974
	Hamaoka-2	BWR	840	1977

Table 3
(continued)

Country	Reactor	Type	Capacity (MWe gross)	Commercial Operation
Japan (continued)	Takahama-2	PWR	826	1975
	Genkai-1	PWR	559	1975
	Fukushima-4	BWR	784	1976
	Fugen ATR	ATR	200	1976
	Fukushima-5	BWR	784	1975
	Fukushima-6	BWR	1,167	1976
	Tokai-2	BWR	1,167	1976
	Mihama-3	PWR	826	1976
	Onagawa-1	BWR	524	1977
	Ohi-1	PWR	1,175	1977
	Ohi-2	PWR	1,175	1977
	Ikata-1	PWR	566	1977
	Hamaoka-3	BWR	1,167	1978
	Genkai-2	PWR	559	1978
	Hokiruku-1	PWR	500	1977
	Fukushima-7	BWR	1,167	1978
	Fukushima-8	BWR	1,167	1979
	Ikata-2	PWR	566	1979
	Fukushima-9	BWR	1,167	1978
	Fukushima-10	BWR	1,167	1979
	Kansai-8	PWR	1,200	1979
	Genkai-3	PWR	826	1980
	Shimane-2	BWR	784	1980
	Namie-1	BWR	784	1979
	Hamaoka-4	BWR	1,167	1980
	Fukushima-11	BWR	1,167	1980
	Fukushima-12	BWR	1,167	1980
	Kansai-9	PWR	1,200	1980
	Kansai-10	PWR	1,200	1980
	Hokkaido-1	BWR	350	1980
Mexico	Laguna Verde-1	BWR	674	1977
	Laguna Verde-2	BWR	674	1978
Netherlands	Dodewaard	BWR	54	1968
	Borssele-1	PWR	477	1973
	Borssele-2	LWR	1,000	1979
South Korea	Kori-1	PWR	595	1976
	Kori-2	PWR	595	1979
Spain	Garoña	BWR	460	1971
	Zorita	PWR	160	1968
	Almaraz-1	PWR	930	1977
	Lemoniz-1	PWR	930	1977
	Asco-1	PWR	930	1977
	Almaraz-2	PWR	930	1978
	Lemoniz-2	PWR	930	1978
	Cofrentes	BWR	974	1978
	Asco-2	PWR	930	1979
	Santillan	PWR	1,000	1980
Sweden	Oskarshamn-1	BWR	460	1971
	Ringhals-1	BWR	762	1974
	Oskarshamn-2	BWR	600	1974
	Ringhals-2	PWR	809	1974
	Barsebäck-1	BWR	600	1975
	Ringhals-3	PWR	900	1977
	Barsebäck-2	BWR	600	1977
	Forsmark-1	BWR	940	1978
	Ringhals-4	PWR	900	1979
	Forsmark-2	BWR	940	1980

Table 3
(continued)

Country	Reactor	Type	Capacity (MWe gross)	Commercial Operation
Switzerland	Beznau-1	PWR	364	1969
	Beznau-2	PWR	364	1971
	Mühleberg	BWR	326	1971
	Leibstadt	BWR	1,000	1978
	Gösgen	PWR	960	1978
	Kaiseraugst	BWR	932	1979
	Graben	BWR	1,140	1979
Taiwan	Chin-shan-1	BWR	636	1977
	Chin-shan-2	BWR	636	1978
	Kuo-sheng-1	BWR	986	1979
	Kuo-sheng-2	BWR	986	1980
United Kingdom	Windscale	AGR	40	1963
	Winfrith	SGHWR	103	1967
	Hinkley Pt. B-1	AGR	660	1975
	Hinkley Pt. B-2	AGR	660	1975
	Hunterston B-1	AGR	665	1975
	Hunterston B-2	AGR	665	1975
	Dungeness B-1	AGR	660	1976
	Dungeness B-2	AGR	660	1976
	Hartlepool-1	AGR	666	1977
	Hartlepool-2	AGR	666	1977
	Heysham-1	AGR	666	1977
	Heysham-2	AGR	666	1977
West Germany	Gundremmingen	BWR	250	1966
	Lingen	BWR	252	1968
	Obrigheim	PWR	345	1968
	Wurgassen	BWR	670	1971
	Stade	PWR	662	1972
	Biblis-A	PWR	1,200	1974
	Brunsbüttel	BWR	805	1975
	Biblis-B	PWR	1,300	1976
	Philippsburg-1	BWR	900	1976
	Neckarwestheim	PWR	805	1976
	Isar	BWR	907	1976
	Unterweser	PWR	1,300	1976
	Uentrop	HTGR	309	1977
	Krummel	BWR	1,316	1978
	Philippsburg-2	BWR	900	1978
	Mulheim	PWR	1,295	1978
	Grafenrheinfeld	PWR	1,299	1978
	Wyhl	PWR	1,362	1979
	Gundremmingen-II-1	BWR	1,310	1979
	Grohnde	PWR	1,361	1979
	Gundremmingen-II-2	BWR	1,310	1980
	BASF-1	PWR	409	1980
	Brokdorf	PWR	1,300	1980
Yugoslavia	Krsko	PWR	615	1979

projection of expected growth in non-Communist nuclear generating capacity through 1982 based on plants in operation, under construction, or firmly planned. Table 3 lists all foreign nuclear powerplants that will require enriched uranium fuel that are expected to be in operation in non-Communist countries by the end of 1980. The list is based on source material from individual countries and presents the latest available projections of dates of commercial operation. No allowance is made for slippage in schedules that may occur.

Although most of these plants have been planned for several years, the recent dramatic shift in the relative economics of nuclear and fossil-fueled generating stations may provide additional impetus to some countries' plans to install nuclear powerplants for base load production of electricity. Following the Arab oil embargo and the subsequent rise in petroleum prices, the French, for example, increased their plans for installed nuclear capacity in 1980 from about 13,000 megawatts (MW) to over 22,000 MW, a 67% increase, and 1985 plans were raised by a similar percentage. Favorable nuclear plant economics have become an important consideration in the selection of facilities to provide energy needs. In addition, the political determination of many countries to obtain relatively secure and independent energy sources may also weigh heavily in decisions to accelerate nuclear power plans.

Although electricity generated in new, large nuclear plants is generally cheaper than that from comparable conventional powerplants, uncertainties prevail in the industry which may tend to hold down nuclear growth and consequently the demand for uranium enrichment services. Among general uncertainties affecting medium and long term demand are: the future contribution of electricity to total energy supply, the effect of recently-instituted energy conservation programs, the rate of introduction of fast breeder reactors, the extent to which natural uranium reactors such as the CANDU may supplant LWRs, and the date of introduction and extent of plutonium recycle. (Plutonium produced as a by-product of normal operation of nuclear reactors can be used to replace a portion of the enriched uranium fuel thereby reducing demand for enrichment.) Other forces of more immediate concern currently affecting nuclear power growth to some extent include increased slippage in the construction and licensing of nuclear plants, equipment and material supply bottlenecks, environmental and safety concerns, and the recently-observed difficulty for electric utilities in the US to raise sufficient capital to build nuclear powerplants.

... Recent studies of the cause for slippage of nuclear plants in the US cite several important reasons: changes in regulatory requirements, design changes, poor labor productivity, shortages of both construction and technical personnel, late delivery of components and materials, and environmental challenges. Some of these problems are beginning to be observed in foreign countries as well. The statistical base for analysis of most of these factors is limited, but it can be shown that most of the delay occurs early in the cycle of nuclear powerplant planning and construction. The total time required to bring a nuclear plant into service has averaged about 8-10 years in the US and 5-6 years in other Western countries. The average time required from start of construction to commercial operation, however, has been about 57 months in the US and approximately 60 months in foreign countries. The involved regulatory requirements in the US thus appear to account for the large difference in total time. Some improvement is expected as the use of standard reactor designs becomes more prevalent thus reducing some of the more lengthy regulatory procedures.

Successful energy conservation measures and inflation are the prime causes of the rash of recent utility announcements deferring the construction of about 20% of planned nuclear capacity additions in the US. Although some utilities are now reporting operating costs at nuclear plants one-half those at comparable oil-fired plants, the relatively high capital intensity of a nuclear power station usually means that nuclear capacity is the first to be deferred in today's tight money market. Industry sources believe that despite the deferrals (and one outright cancellation -- a 2,300 MW two-unit station in Michigan), nuclear power in the US will continue to grow at a rapid pace, and the easing of the strain on equipment suppliers will ensure an orderly expansion of production capability. There is little indication at the present time of foreign capital mobilization constraints similar to those now existing in the US, but deferrals may occur probably on a more limited scale.

All of these problems are reflected in medium and long term forecasts of nuclear generating capacity. Uncertainty is evident in the comparison of several recent forecasts of medium term foreign capacity (1980-1990) shown in Table 4.

Major Sources of Enrichment Demand

United States. As of mid-1974, the US had 41 nuclear power reactors in operation with an installed capacity of

Table 4

Comparison of Medium Term Forecasts of Nuclear Generating Capacity
(Net Electrical Gigawatts)*

Country Group	Source	1980	1985	1990
European Community	EC Commission (June 1974)	64.9	176.3	-
	OECD Nuclear Energy Agency (March 1974)			
	"basic program"	55.1	129	264
	"accelerated program"	58	167	367
	OECD/IAEA, Uranium Resources, Production and Demand (August 1973)	57.6	134	283
Other OECD Europe	OECD Nuclear Energy Agency (March 1974)			
	"basic program"	23.7	46	81
	"accelerated program"	25	60	113
	OECD/IAEA, Uranium Resources, Production and Demand (August 1973)	23.7	50	90
Total Non-Communist Foreign	EC Commission (June 1974)	134.4	251.3	-
	USAEC Case Y Forecast (February 1974)	114	308	574

* The difference between gross and net capacity, i.e., individual station use, for nuclear powerplants is on the order of five percent.

more than 26,000 MW. An additional 192 nuclear generating units totaling about 200,000 MW were either ready for operation, under construction, or planned. The latest USAEC forecast indicates that domestic nuclear generating capacity in 1990 will be five times that of 1980:

1980	85,000 - 112,400 MW
1985	230,900 - 275,000 MW
1990	410,000 - 575,000 MW

It will have increased from about 15% of total generating capacity in 1980 to 40% in 1990. Despite pressures to increase the nuclear share of electricity production, offsetting forces such as those mentioned previously are likely to restrict US nuclear capacity to the lower ends of these ranges especially in the earlier years. AEC forecasts anticipate that annual US enrichment requirements will rise from something in the range of 11-14 million SWU in 1980 to 36-53 million SWU in 1990 assuming full plutonium recycle. If plutonium is not recycled in US light water reactors, US demand for enrichment services will be about 7% higher in 1980 and 12% higher in 1990.

Japan. Japan has the largest nuclear power program outside the US. Currently operating eight power reactors with a combined capacity of 3,869 MW, Japan plans to increase its nuclear generating capacity to 33,300 MW in 1980 and

74,500 MW in 1985. The 1985 figure will represent 31% of total electric generating capacity. Although Japan plans to include breeders and high temperature gas reactors in its nuclear power mix, LWRs will predominate. Annual Japanese enriched uranium requirements are expected to grow from 2-3 million SWU in the late 1970s to about 8 million SWU by 1985. Japan has signed enrichment contracts with the US for almost 60 million SWU and with Eurodif for 10 million SWU, but cumulative Japanese enrichment demand to 1990 is likely to approach 100 million SWU.

France. The French now operate ten nuclear power reactors with a total capacity of 3,022 MW, including a 250-MW fast breeder reactor. Most of existing French capacity is in natural uranium-fueled reactors, but all new plants will use enriched uranium. Recent uncertainty concerning the availability of oil and rising oil prices spurred French officials to decide to build only nuclear electric powerplants after 1975. Although France's next nuclear power stations are not due for operation until 1976, the national electric utility, EDF, has announced an ambitious program to have 22,400 MW in operation by the end of 1980 and 54,400 MW by 1985, at which time nuclear energy is expected to provide 70% of French electricity requirements. French industry is currently expanding capacity for production of nuclear reactors and related components to meet these targets. EDF has estimated that French enrichment demand will grow from about 3 million SWU per year in 1979-80 to almost 6 million SWU annually by 1985.

West Germany. West Germany, at the present time, has in operation seven commercial nuclear plants with a total capacity of almost 3,500 MW. Installed nuclear electric generating capacity in 1980 is expected to be 22,400 MW which will satisfy about one-quarter of West German needs for electricity. Plans call for 45,000 MW of capacity in 1985 and between 80,000 and 100,000 MW in service by 1990. The demand for uranium enrichment services by West German electric utilities will exceed 2 million SWU per year in the late 1970s, could grow to about 5 million SWU annually by the middle of the next decade, and reach 8-9 million SWU per year by 1990. West Germany currently hold enrichment contracts with the US, Urenco, Eurodif, and the Soviet Union.

United Kingdom. Prior to 1970, the UK had the largest nuclear generating capacity in the world. Now operating 26 power reactors of its own design using natural uranium fuel, plus four prototype plants based on three other reactor technologies, the UK's nuclear capacity totals 6,300 MW. The second phase of the British program will see ten British-designed advanced gas reactors (AGRs) -- long delayed by technical problems -- installed between 1975 and 1977 increasing nuclear capacity to almost 13,000 MW. After much debate as to the merits of various reactor systems including the US LWR and the CANDU, the British have chosen another domstic design, the steam-generating heavy water reactor (SGHWR), for their next increment in capacity. Although the AGR and the SGHWR both require enriched uranium fuel, the shift in reactor technology coupled with uncertainty about further nuclear power development should hold the UK's enrichment demand below one million SWU per year through the early 1980s.

Spain. At present, Spain's nuclear capacity is limited to 1,138 MW in three plants. However, seven additional reactors now under construction are expected to add 6,500 MW by the end of 1978. Total nuclear capacity in Spain in 1980 will be about 8,600 MW, 23% of total electric generating capacity. The national electric plan calls for 23,000 MW in nuclear plants by 1985, equivalent to total Spanish capacity in all powerplants at the present time. With the exception of one 518-MW plant now in operation, all of Spain's nuclear reactors will use enriched uranium fuel. Spanish demand for enrichment services is expected to exceed one million SWU annually by 1979-80, and could reach 2 million SWU per year by 1985.

Sweden. Sweden has four nuclear power reactors in operation with a combined capacity of 2,631 MW. An additional six units now under construction are all scheduled for service before the end of 1980, at which time total nuclear generating capacity will be 7,500 MW. These ten reactors should account for one-third of Swedish electricity production. Official plans call for 16,000 MW of nuclear capacity by 1985 and 24,000 MW by 1990. At the end of the next decade, nuclear powerplants are expected to provide 60% of electricity requirements in Sweden. The possibility of using nuclear reactors to supply district steam heating as well as electricity to major urban areas is being considered. All Swedish nuclear plants will require enriched uranium fuel and annual demand for enrichment services probably will increase from about one million SWU in 1980 to more than 2 million SWU by 1990.

Others. In addition to the countries listed above, Italy, Finland, Belgium, Taiwan, and Switzerland have planned relatively large nuclear power programs based on enriched uranium-fueled reactors and will have sizable requirements for uranium enrichment services. The aggregate nuclear generating capacity planned for 1980 operation in these five countries is more than 20,000 MW, and their combined annual enrichment requirements are expected to exceed 2 million SWU by 1980. Currently operating nuclear powerplant capacity is as follows: Italy, 627 MW; Belgium, 410 MW; and Switzerland, 1,054 MW.

Short and Medium Term Enrichment Demand in the West

Individual nuclear power reactor plans in non-Communist countries can be used to estimate with some degree of reliability short term requirements for uranium enrichment services. (Communist enrichment demand is not considered here as it is unlikely that the USSR or East European countries would seek enrichment services outside the bloc.) The majority of plants scheduled for operation in 1982 or before are already under construction or have major components on order. Virtually all of these plants are US-designed light water reactors, and although some slippage may occur for some of the same reasons now being experienced in the US, such delays are not expected to amount to more than a year or so in most cases.

Separate reactor enrichment requirements for first core loading and subsequent annual reloads were calculated for each plant now in operation or planned for service by 1982. Over 200 individual plants were considered. Enrichment services were assumed to be required approximately two years prior to the first full year of commercial operation (rounded down to the nearest six months) and enrichment for annual reloads beginning in the first year of plant operation. This lag is necessary to allow time for enrichment of the uranium, fabrication of the reactor fuel, fuel loading, and bringing the reactor up to full power as well as for transportation. It is for this reason that although nuclear generating capacity was projected to 1982, short term enrichment demand is shown only through 1980.

The individual reactor estimates were aggregated by country and further combined into the groups shown in Table 5. The USAEC forecast of US enrichment demand (Case D -- the most likely domestic case) was used to obtain total short term non-Communist requirements. No recycle of plutonium in reactor loadings is considered in this short term projection. Although plutonium is now being recycled both in the US and in foreign countries on a very limited basis, it is likely that the expected date of introduction of plutonium recycle on a large scale will be delayed beyond 1977 as planned, primarily because of an anticipated shortage of fuel reprocessing capacity in the mid- to late 1970s.

The procedure used to estimate short term enrichment demand in foreign countries is basically the same as that

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Table 5

Projected Short Term Non-Communist Enrichment Requirements
(million SWU)*

	1973	1974	1975	1976	1977	1978	1979	1980	Total
European Community	1.6	0.9	3.0	2.2	4.2	4.9	6.4	7.0	30.2
Other OECD Europe	0.3	0.4	0.9	1.3	1.8	2.0	2.5	4.0	13.2
Japan	0.4	0.7	1.7	1.6	1.6	2.9	3.2	3.4	15.5
Other Countries**	Negl.	Negl.	0.4	0.3	0.5	0.8	1.0	1.7	4.7
Total Foreign	2.3	2.0	6.0	5.4	8.1	10.6	13.1	16.1	63.6
United States***	2.8	3.4	5.6	5.7	7.3	9.9	11.4	15.2	61.3
Total Non-Communist	5.1	5.4	11.6	11.1	15.4	20.5	24.5	31.3	124.9

* Data shown are based on enrichment plant tails assay of 0.30 percent, nuclear powerplant availability of 75 percent, and <u>no plutonium recycle</u>. Enrichment requirements for BWRs, PWRs, HTGRs, AGRs, and the Japanese ATR are calculated from projected gross electrical capacity in individual plants using reactor characteristics in USAEC WASH-1139 (74), <u>Nuclear Power Growth 1974-2000</u>. Enrichment requirements for other reactors are calculated from burnup and degree of enrichment data for individual plants and assume natural uranium feed to enrichment plants.

** Includes Brazil, Egypt, India, Iran, Israel, Mexico, Philippines, South Africa, South Korea, Taiwan, Thailand, and Yugoslavia.

*** USAEC Case D Forecast (without plutonium recycle).

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used by the AEC's Office of Planning and Analysis in its published forecasts of nuclear power growth and enrichment demand: Nuclear Power Growth, 1974-2000. The input data (number, type, size, and scheduling of plants) for specific foreign countries, however, reflect some of the changes that have occurred since preparation of that forecast (the French program acceleration, for example). The AEC's most likely forecast of enrichment demand in non-Communist countries other than the US (Case Y) is compared with the present projection for the last several years of this decade (in million SWU) below.

	Data from Table 5	AEC Case Y
1975	6.0	5.1
1976	5.4	5.8
1977	8.1	6.8
1978	10.6	10.5
1979	13.1	11.5
1980	16.1	11.6

Neither forecast includes plutonium recycle. It is likely that the major reason for differences in the later years is the increased planning for nuclear power in several countries as a result of the oil embargo and higher conventional fuel prices. Such accelerated planning for nuclear powerplants has been regarded as sufficiently realistic to allay previous concern about a possible enrichment glut in Europe and the two new European enrichment suppliers, Urenco and Eurodif, have already obtained commitments for most of their planned capacity.

Although short term enrichment demand can be described with some accuracy on the basis of individual powerplant requirements (assuming the announced nuclear programs remain on schedule), projections of medium term enrichment requirements (through about 1990) must rely on a more generalized approach based largely on extrapolations of short term trends and varying assumptions concerning future energy and electricity consumption patterns. Despite the fact that most of the enriched uranium needed throughout remainder of this decade has already been contracted for, a short term forecast probably is the most useful basis for estimating medium term demand. An annual rate of growth in demand for enrichment services of the size implicit in Table 5 (almost 30%) is not, however, likely to continue into the 1980s, because it reflects some degree of over-installation of nuclear capacity during the early to mid-1970s.

The forecasts developed by the AEC of enrichment re-requirements in the medium term (1981-1990) in the US and foreign non-Communist countries are presented in Table 6. The various case estimates (four for the US and three for foreign countries) have been combined to show annual demand in terms of ranges. The lowest estimates assume continuation of the present trend toward increased slippage in reactor construction and relatively low long term demand for electric energy. The highest estimates assume improvements in the regulatory process and construction time and postulate high growth rates for electricity demand as well as increased use of nuclear plants for electricity generation.

Although these forecasts were published in February 1974 and the required input data were developed even earlier, the range of estimated demand for enrichment appears reasonable in light of the tremendous uncertainties involved, particularly as to exact dates of completion of planned nuclear powerplants. The forecasts are substantiated in general by comparing some of the individual country estimates of enrichment demand. The three largest foreign consumers of enriched uranium for nuclear reactor fuel -- Japan, France, and West Germany -- can be assumed to be representative of foreign demand as a whole in the medium term. The demand for the year 1985 from individual country sources (Japan: Chairman of the Japan Industrial Forum

Table 6

Medium Term Non-Communist Enrichment Demand Forecasts*
(million SWU)

	United States	Foreign**	Annual Total (rounded)
1981	13.3-16.3	11.8-16.0	25- 32
1982	14.9-19.6	13.8-18.4	29- 38
1983	16.9-20.7	13.7-21.9	31- 43
1984	19.2-24.2	17.8-25.3	37- 50
1985	23.0-28.5	20.4-28.9	43- 57
1986	24.9-32.9	22.6-33.3	48- 66
1987	27.4-38.1	26.5-38.1	54- 76
1988	30.7-42.8	31.3-43.6	62- 86
1989	32.9-47.9	33.4-47.7	66- 96
1990	36.3-53.4	36.2-51.8	72-105

* This table presents USAEC forecasts published in WASH-1139 (74), Nuclear Power Growth 1974-2000, February 1974, based on 0.30% enrichment plant tails assay, nuclear powerplant availability of 75%, and full plutonium recycle.

** Data for centrally-planned economies included in published tables have been removed.

Committee on Uranium Enrichment; France: the national utility, Electricité de France; West Germany: Chairman of the Board of Directors of a large German electric utility) is shown below.

Japan	8.0 million SWU
France	5.7
West Germany	5.0
	18.7 million SWU

These three countries represent 58% of projected cumulative enrichment requirements in foreign non-Communist countries through 1980. If the same relationship is assumed for 1985, total enrichment demand would approximate 32 million SWU. It is unclear whether the country estimates for Japan and France make any allowance for plutonium recycle; the one for West Germany does not. If a plutonium recycle savings of 2.6 million SWU is used (based on the AEC Case Y forecast of 1985 demand), the 32 million SWU of enrichment demand posited for the year 1985 would become 29.4 million SWU, just slightly above the upper limit of the AEC projection. Until the comprehensive AEC forecast can be updated to reflect recent developments both in the US and foreign countries, it remains the most reliable indicator of medium term uranium enrichment demand in the Free World.